ROUNDABOUT IMPLEMENTATION REPORT

Interim Draft

MILESTONE ROTARY

MILESTONE ROAD/ ORANGE STREET/ OLD SOUTH ROAD/ SPARKS AVENUE

NANTUCKET, MASSACHUSETTS

PREPARED FOR:

NANTUCKET PLANNING AND ECONOMIC DEVELOPMENT COMMISSION

August 2006
06914.800

Ourston Roundabout Engineering

Ourston Roundabout Engineering

August 10, 2006

Nantucket Planning and Economic Development Commission
16 Broad Street
Nantucket, MA 02554

Attention: Mr. T. Michael Burns, AICP
Transportation Planner

Dear Michael:

Re: Roundabout Implementation Report -- Interim Draft
Milestone Rotary
Milestone Road/ Orange Street/ Old South Road/ Sparks Avenue
Our Project No. 06914.800

Ourston Roundabout Engineering, Inc. has been retained to re-design the Milestone Rotary so that it functions as a safe and efficient roundabout. The rotary is currently experiencing congestion on the single-lane Old South Road entry. Further development is planned to the south that will exacerbate this condition. There is currently no lateral deflection for motorists entering the existing rotary from Orange Street and Milestone Road, where high-speed angle collisions are possible with circulating traffic. Finally, there is heavy pedestrian and bicycle traffic during the summer season that would be better served by a re-design of the intersection.

The roundabout concept is shown as Figure 2 at the end of this report. It has an inscribed circle diameter (ICD) of 140 feet, and is located such that a pedestrian area can be accommodated between Sparks Avenue and Old South Road. Sidewalks are located around the rest of the roundabout as well, and bicycle lanes are shown on Orange Street that terminate at the roundabout. The size and location of the roundabout would impact the lands between Old South Road and Milestone Road. There would be minor impacts to the driveways on the east side of Orange Street, and the splitter island on this leg would block access to these driveways to about the same extent as is currently the case. The Orange Street and Milestone Road approaches have been re-aligned to create deflection prior to entry.

The roundabout can accommodate a WB-50 design vehicle. Judging by the size of the existing rotary this is the largest truck currently using the intersection. A truck apron is provided for vehicle over-tracking. It should be noted that trucks will need to use both lanes of the entry when:

- Entering the roundabout from Sparks Avenue.
- Turning right from Old South Road to Milestone Road.
- Turning left from Orange Street to Milestone Road.

The latter case is similar to a truck swinging wide to make a right turn at a conventional intersection, and is common at many roundabouts. It may be possible to refine this left turn with further design work so trucks can stay in their own lane at the Orange Street entry.

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All entries flare from one to two lanes. The Orange Street and Old South Road entries are configured as a left plus and through/right turn, and the Milestone Road and Sparks Avenue entries are configured as a left/through plus a right turn. This enables the exits to be single-lane, like the existing rotary, and keeps the ICD small. To educate about correct lane use, the truck apron is shaped so that motorists entering from Milestone Road or Sparks Avenue and making a left turn will be "spiralled out" to the outer lane of the circulatory road so they are not trapped and forced into making an unsafe lane change inside the roundabout.

A capacity analysis of the roundabout was undertaken using the computer program RODEL. The results show the roundabout would be able to handle current traffic volumes more efficiently than the existing rotary, and future traffic growth in particular at the Old South Road entry. Average delays to motorists would be lower than if the existing rotary were to remain in place. It should be noted however that future traffic queues may be high on the Sparks Avenue approach during the PM peak hour, and periodically affect driveway access during these times.

From the results of the design work so far, a safe and efficient roundabout is possible at this location. The roundabout will have a reduced potential for collisions, and better serve pedestrians and bicyclists than the existing rotary. We therefore recommend proceeding with completion of the design as set out in our proposal.

The next steps in terms of design work and the final report for the Milestone Roundabout include:

- Finalizing the design, including establishing limits of construction.
- Completing the remaining design elements. These include finalizing pedestrian facilities such as sidewalks and pedestrian crossings, finalizing the location of future bicycle lanes, determining any grading impacts and sight distance requirements, making recommendations concerning roundabout signs, and making recommendations concerning landscaping and illumination.
- Adding the RODEL capacity analysis.
- Providing a discussion on construction staging and public consultation.

Yours truly,

OURSTON ROUNDABOUT ENGINEERING, INC.

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TABLE OF CONTENTS

FIGURES

APPENDICES

This report was prepared with funding from the Massachusetts Highway Department
and the Federal Highway Administration.

1.0 INTRODUCTION

1.1 BACKGROUND

Ourston Roundabout Engineering, Inc. has been retained by the Nantucket Planning and Economic Development Commission to re-design the Milestone Rotary so that it functions as a safe and efficient roundabout.

The current rotary is located at the intersection of Old South Road, Sparks Avenue, Orange Street, and Milestone Road, and serves motorists traveling between the downtown area, Nantucket Memorial Airport, Mid-Island, Siaconset, and Madaket. It operates as a typical rotary with tangential entries under YIELD control, with the exception of the Sparks Avenue approach with intersects at 90 degrees under STOP control. The Orange Street and Milestone Road legs have entries that flare from one to two lanes. The other two legs have single-lane entries. All exits are single-lane. The inscribed circle diameter (ICD) of the rotary is about 120 feet.

The rotary is currently experiencing congestion on the single-lane Old South Road entry. Further development is planned to the south that will exacerbate this condition. There is currently no lateral deflection for motorists entering the existing rotary from Orange Street and Milestone Road, where high-speed angle collisions are possible with circulating traffic. Finally, there is heavy pedestrian and bicycle traffic during the summer season that would be better served by a re-design of the intersection.

1.2 ROTARIES AND ROUNDABOUTS

Rotaries are a common means of traffic control in the northeast, having been installed in Massachusetts, New York, New Jersey, and several other states starting in the 1940's. They generally fell out of favor by the 1960's because of operational problems, and many were replaced with traffic signals or grade separated interchanges. The operational problems with rotaries include:

- One or more entries that are tangential to the central island. This means that entering motorists experience little or no lateral deflection, and thus in the absence of traffic control (or if they ignore the traffic control), they can enter the rotary at speed. This is evident on the Orange Street and Milestone Road approaches to the Milestone Rotary. Fortunately this highly probable collision pattern does not seem to be manifesting itself as a recorded collision problem, but the potential is there.

- Inconsistent traffic control. Some rotaries operated with YIELD or STOP control for circulating motorists, rather than entering motorists. This meant that under high traffic flows circulating traffic could back up and block traffic from entering, eventually locking the entire rotary. This is not the case with the Milestone Rotary, as all entries are under YIELD (or STOP) control.

- Inefficient use of space to achieve capacity. Rotaries generally achieve higher capacities by increasing size. This allows more traffic to circulate at the same time or be stored in the circle, or increases weaving distances to allow more time for motorists to changes lanes to find their exit. Unfortunately, making the rotaries larger also led to higher speeds and more frequent and serious collisions. The Milestone Rotary is too small to exhibit these characteristics, but it could benefit from a re-design to increase traffic capacity.

Figure 1 shows a large rotary that has now been replaced with a roundabout in Kingston, New York. Note the tangential entries, similar to the Milestone Rotary. The smaller roundabout is proving to be safer and have higher capacity than the former rotary.

FIGURE 1
Rotary Being Replaced with Roundabout, Kingston, New York

Photo: New York Department of Transportation

Well-designed roundabouts do not experience the problems of rotaries because entries are always under YIELD control, because there is deflection on the approaches to slow motorists before they enter, and because it is safe to accommodate pedestrians and other users due to slow traffic speeds and consistent conditions for motorists.

2.0 THE ROUNDABOUT CONCEPT

2.1 CONCEPT DEVELOPMENT

We initially developed two roundabout concepts to "explore the design space". This is what we term Stage 1 design, where concepts are developed to explore capacity, safety, and cost trade-offs. Usually the costs involve grading or property impacts.

The first concept was a roundabout with an ICD of 180 feet. This is considerably larger than the existing rotary in order to develop enough deflection for the Milestone Road to Orange Street movement using the existing alignment of Milestone Road. The main advantage of this concept was more vehicular capacity due to the larger size and wider entry on Sparks Avenue. The main disadvantage was that more property would be required between Old South Road and Milestone Road, and the parking lot between Sparks Avenue and Old South Road.

The second concept had a smaller ICD of 140 feet, somewhat larger than the existing rotary. In this case deflection was achieved for the Milestone Road to Orange Street movement by re-aligning part of Milestone Road from about 250 feet back from the edge of the roundabout. The main advantage of this concept was less property required overall. However, there would be peak hour queuing on the Sparks Avenue approach in the future because only a single-lane entry could be developed, and there would still be impacts to the parking lot between Sparks Avenue and Old South Road.

Both concepts developed deflection for the Orange Street entry by re-aligning the approach, which meant minor impacts to driveways on the east side of Orange Street.

Based on discussions with the Nantucket Planning and Economic Development Commission, it was determined that the second concept was favored, but with modifications that would eliminate impacts to the parking lot between Sparks Avenue and Old South Road.

2.2 DESCRIPTION

The final concept also has an ICD of 140 feet, but has been moved to the east compared with the second concept so that a pedestrian area can be accommodated between Sparks Avenue and Old South Road. This has again resulted in impacts to the lands between Old South Road and Milestone Road. Deflection for the Orange Street and Milestone Road approaches has been achieved as before. There are still minor impacts to the driveways on the east side of Orange Street, and the splitter island on this leg would block access to these driveways to about the same extent as is currently the case.

The final roundabout concept is shown as Figure 2 at the end of the report. It represents a Stage 2 design, where a horizontal layout has been established and operational performance predicted. We have added some Stage 3 design elements such as pedestrian facilities and bicycle lanes on Orange Street that terminate at the roundabout.

The roundabout can accommodate a WB-50 design vehicle. Judging by the size of the rotary this is the largest truck currently using the intersection. A truck apron is provided for vehicle over-tracking. It should be noted that trucks will need to use both lanes of the entry when:

- Entering the roundabout from Sparks Avenue.
- Turning right from Old South Road to Milestone Road.
- Turning left from Orange Street to Milestone Road.

The latter case is similar to a truck swinging wide to make a right turn at a conventional intersection, and is common at many roundabouts. It may be possible to refine this left turn during Stage 3 design so trucks can stay in their own lane at the Orange Street entry.

All entries flare from one to two lanes. The Orange Street and Old South Road entries are configured as a left plus a through/right turn, and the Milestone Road and Sparks Avenue entries are configured as a left/through plus a right turn. This enables the exits to be single-lane, like the existing rotary, and keeps the ICD small. To educate about correct lane use, the truck apron is shaped so that motorists entering from Milestone Road or Sparks Avenue and making a left turn will be "spiralled out" to the outer lane of the circulatory road so they are not trapped and forced into making an unsafe lane change inside the roundabout.

It should be noted that we pulled the outer curb of the Old South Road entry off the ICD in order to accommodate the WB-50 right turn from Old south Road to Milestone Road. This results in a yield line straighter than desirable. Straight yield lines such as this make it difficult for motorists in the right lane to see circulating traffic past motorists in the left lane, and they can end up jockeying for position and encroaching into the circulatory road. This problem is currently evident with the straight yield line on the Milestone Road entry.

2.3 CAPACITY ANALYSIS

The decision to have all entries flare from one to two lanes was made through a capacity analysis using the computer program RODEL.[1] The program is based on research from a comprehensive study undertaken in the United Kingdom in the late 1970s of the entry capacities of roundabouts at 86 public road sites. From the research very robust empirical formulas for capacity prediction were developed from direct measurement.[2] The formulas relate the capacity of a roundabout entry to the circulating flow past that entry, and the effect of 6 geometric design parameters: inscribed circle diameter (ICD), entry width, road half width, effective flare length, entry radius and entry angle. Following the initial research the methods were validated to confirm the suitability of the parameters, the most recent on 35 roundabouts in 1997 which concluded that no changes to the original formulas were necessary. Our early experience is proving the UK formulas to be valid for US roundabouts and conditions.

The analysis was carried out using the 2004 traffic counts and 2014 traffic forecasts in the *Traffic Study & Strategy for the Mid-Island Area* dated July 8, 2005. It was not possible to model the existing rotary with RODEL because its geometric parameters are outside the normal operating range of the program.

The entries were checked on an individual lane basis, since RODEL assumes equal lane utilization rather than the left plus through/right or left/through plus right turn configurations used here. The highest values are expected to be during the 2014 PM peak hour on the Sparks Avenue entry, with average delays in the order of 40 seconds per vehicle. This is relatively high for a roundabout, but is a future worst-case condition, about the same as delays currently being experienced by motorists entering the existing rotary from Old South Road during peak times. The second-highest average delay is expected during the 2014 PM peak hour on the Orange Street entry, at about 20 seconds per vehicle. The Old South Road and Milestone Road entries would experience low average delays by 2014.

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1 RODEL 1 – Interactive Roundabout Design, Rodel Software Ltd. and Staffordshire County Council, United Kingdom (Licensed to Ourston Roundabout Engineering, 2000).

2 R.M. Kimber, *The Traffic Capacity of Roundabouts*, LR942, TRL, 1980.

The highest 95th percentile queue is expected during the 2014 PM peak hour, on the Sparks Avenue entry, at about 20 vehicles. This is fairly high, and may affect driveway access along Sparks Avenue during these times. The second-highest 95th percentile queue is expected on the Orange Avenue entry during the 2014 PM peak hour, at less than 10 vehicles. Again, these are future worst-case conditions.

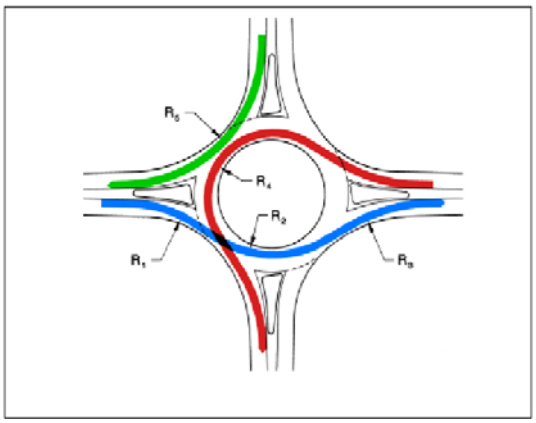
2.4 DEFLECTION

In addition to accommodation of the design vehicle, several design checks were conducted through the Stage 1 design process, and finalized during Stage 2 design. The most important is entry deflection.

Deflection is considered a "proxy" for safety. The more deflection an entry has, generally the more safe it should be. This is because deflection will slow motorists, making them more likely to yield on entry and less likely to cause entry-circulating collisions. However, there are limits. An entry that is over-deflected can cause rear-end or loss of control collisions.

Worst-case or fastest-path speeds were determined for each entry to calculate deflection. Figure 2 illustrates the radii corresponding to various fastest-path checks from the FHWA publication *Roundabouts: An Informational Guide*.

FIGURE 3
Vehicle Path Radii (from the FHWA Guide)



- R_1 = Entry path radius
- R_2 = Circulating radius
- R_3 = Exit path radius

- R_4 = Left turn radius
- R_5 = Right turn radius

Source: FHWA Guide

A fastest-path check is carried out by drawing a curve that represents the straightest possible path through a roundabout. The path should be offset 5 feet from the face of curb or 3 feet from a painted centerline, and is best represented by a smooth spline from entry to exit. For example the R_1, R_2, R_3 spline comes within 5 feet of the curb at the entry, 5 feet of the central island, and 5 feet of the curb at the exit. The minimum radii of the arcs along this spline correspond to the R_1, R_2, and R_3 radii. Of these, the R_1 entry path radius is usually the most critical. On skewed intersections sometimes it is the R_5 or right turn radius.

A balanced design minimizes the differences between the various R_1 values. The R_3 exit path radius is not a critical check unless the value is overly small, as a motorist's ability to accelerate from the R_2 position to the exit area rarely exceeds the calculated exit speed owing to the R_3 path. R_4 is governed by the size of the central island and generally operates at the lowest speed.

Contrary to expectation, a tight entry radius and straight alignment of the entry into the central island does not always equate to a low entry path radius, as evident in Figure 4. Entry radius comes from the geometric design, while entry *path* radius comes out of the composition of the design (arrangement of entry alignment and circle) and is a result of the fastest-path through a roundabout.

FIGURE 4
Example of Too Little Entry Path Deflection

For the final roundabout concept, we measured the following R_1 values, plus critical R_5 or right turn radius from Milestone Road to Orange Street:

- Orange Street R_1 value of 222 feet, or 28 mph.
- Sparks Avenue R_1 value of 198 feet, or 26 mph.
- Old South Road R_1 value of 245 feet, or 29 mph.
- Milestone Road R_1 value of 213 feet, or 27 mph, and R_5 value of 234 feet or 28 mph.

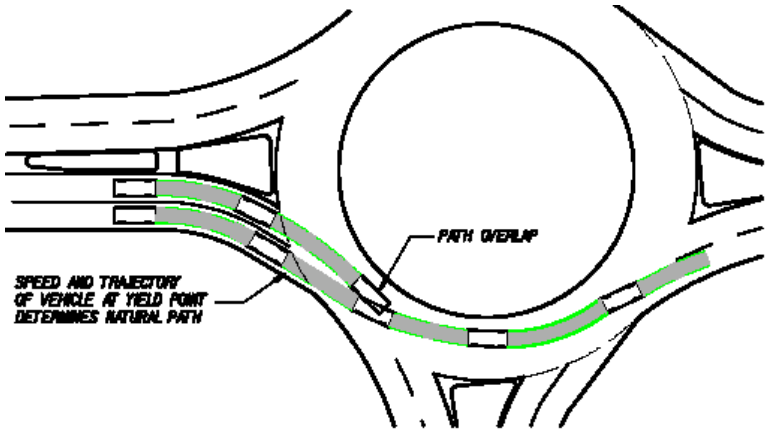
Thus the highest possible speed through the roundabout in the absence of other traffic and ignoring all signs and pavement markings, is less than 30 mph. It should be possible to lower some of these values during Stage 3 design. Figure 5 at the end of the report shows the deflection checks for these movements.

2.5 OTHER DESIGN CHECKS

Figure 6 at the end of the report shows selected WB-50 design vehicle runs through the final roundabout concept.

Another important design check, applicable to multi-lane roundabouts, is that of avoiding path overlap on the entries or exits. The natural path of vehicles can be determined by assuming motorists stay within their lane up to the yield line. At the yield line, they will maintain their natural trajectory into the circulatory road and through to the exit. If the roundabout geometry tends to lead vehicles into the wrong lane, this can result in path overlap. Figure 7 shows an example of entry path overlap. Path overlap can occur at roundabout exits as well.

FIGURE 7
Example of Entry Path Overlap



Source: Wisconsin Department of Transportation Facilities Development Manual

The final roundabout concept was checked to ensure a low probability of entry path overlap, particularly on the Orange Street and Old South Road entries where two vehicles can enter the roundabout and circulate side by side.

A final Stage 2 design check was to ensure that any pedestrian refuge areas on the splitter islands are at least 8 feet wide, to accommodate a bicyclist or person pushing a stroller. The splitter island on the Sparks Avenue leg is too small to accommodate pedestrians, and so pedestrians must cross to the outside of the splitter island as they do with the existing rotary.

2.6 PRELIMINARY COST ESTIMATE

A cost estimate for the re-design of the Milestone Rotary to a roundabout has not been prepared, pending completion of the Stage 3 elements of the design. Based on our experience with similar projects, is it likely the work would cost approximately $500,000. This includes re-alignment of the Orange Street and Milestone Road approaches, utility pole relocations, and some landscaping of the central island. The estimate does not include the acquisition of property.

3.0 CONCLUSIONS

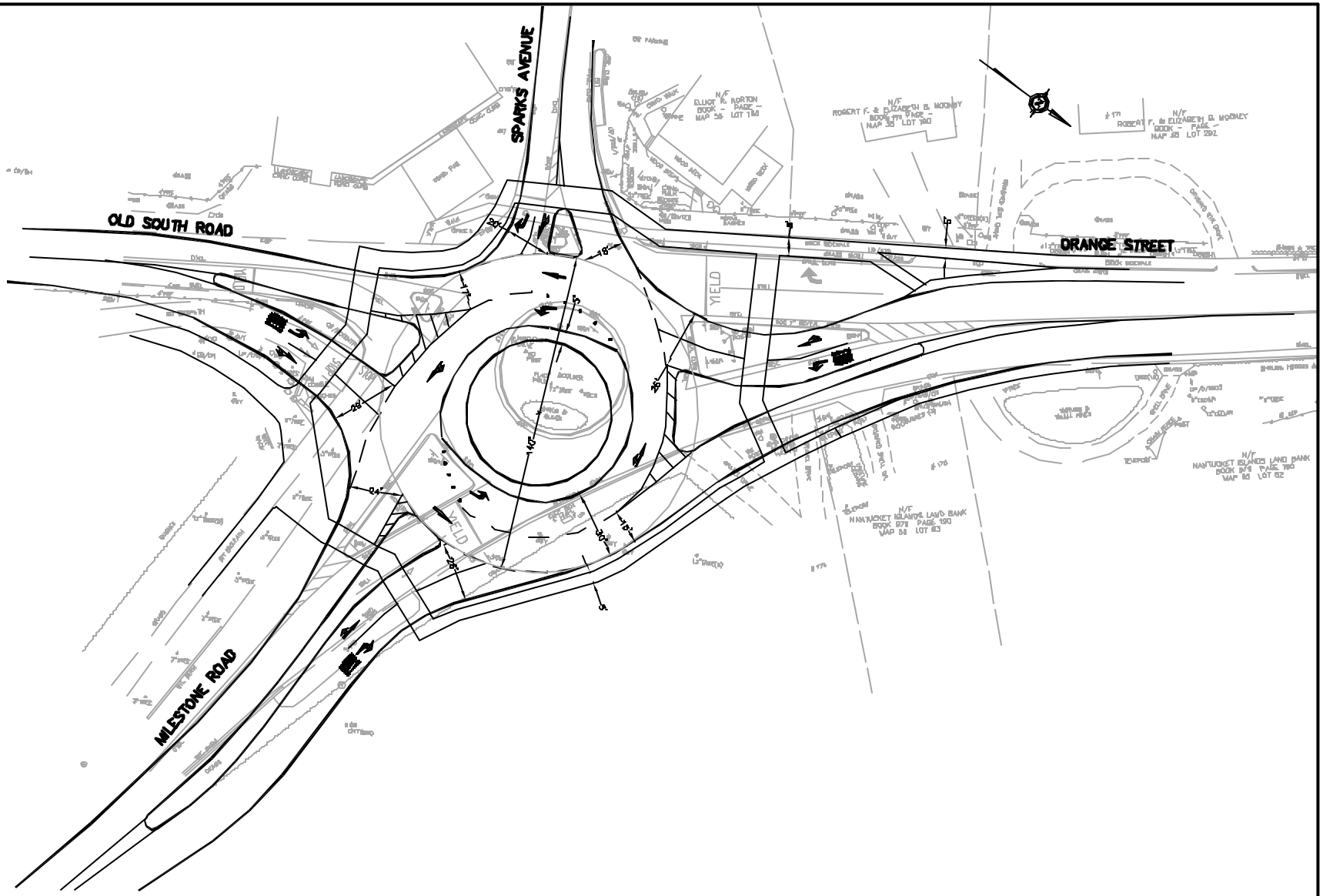
3.1 RECOMMENDATION

From the results of the design work so far, a safe and efficient roundabout is possible at this location. The roundabout will be able to accommodate current traffic volumes and future growth, have a reduced potential for collisions, and better serve pedestrians and bicyclists than the existing rotary. We therefore recommend proceeding with completion of the Stage 2 design, and the remaining Stage 3 design elements.

3.2 NEXT STEPS

The next steps in terms of design work and the final report for the Milestone Roundabout include:

- Finalizing the Stage 2 design, including establishing limits of construction.
- Completing the remaining Stage 3 design elements. These include finalizing pedestrian facilities such as sidewalks and pedestrian crossings, finalizing the location of future bicycle lanes, determining any grading impacts and sight distance requirements, making recommendations concerning roundabout signs, and making recommendations concerning landscaping and illumination.
- Adding the RODEL capacity analysis.
- Providing a discussion on construction staging and public consultation.



MILESTONE ROUNDABOUT - FINAL CONCEPTUAL DESIGN
MILESTONE ROAD / ORANGE STREET / OLD SOUTH ROAD / SPARKS AVENUE
NANTUCKET, MA

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DATE	PROJECT NO.:
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SCALE	FIGURE NO.
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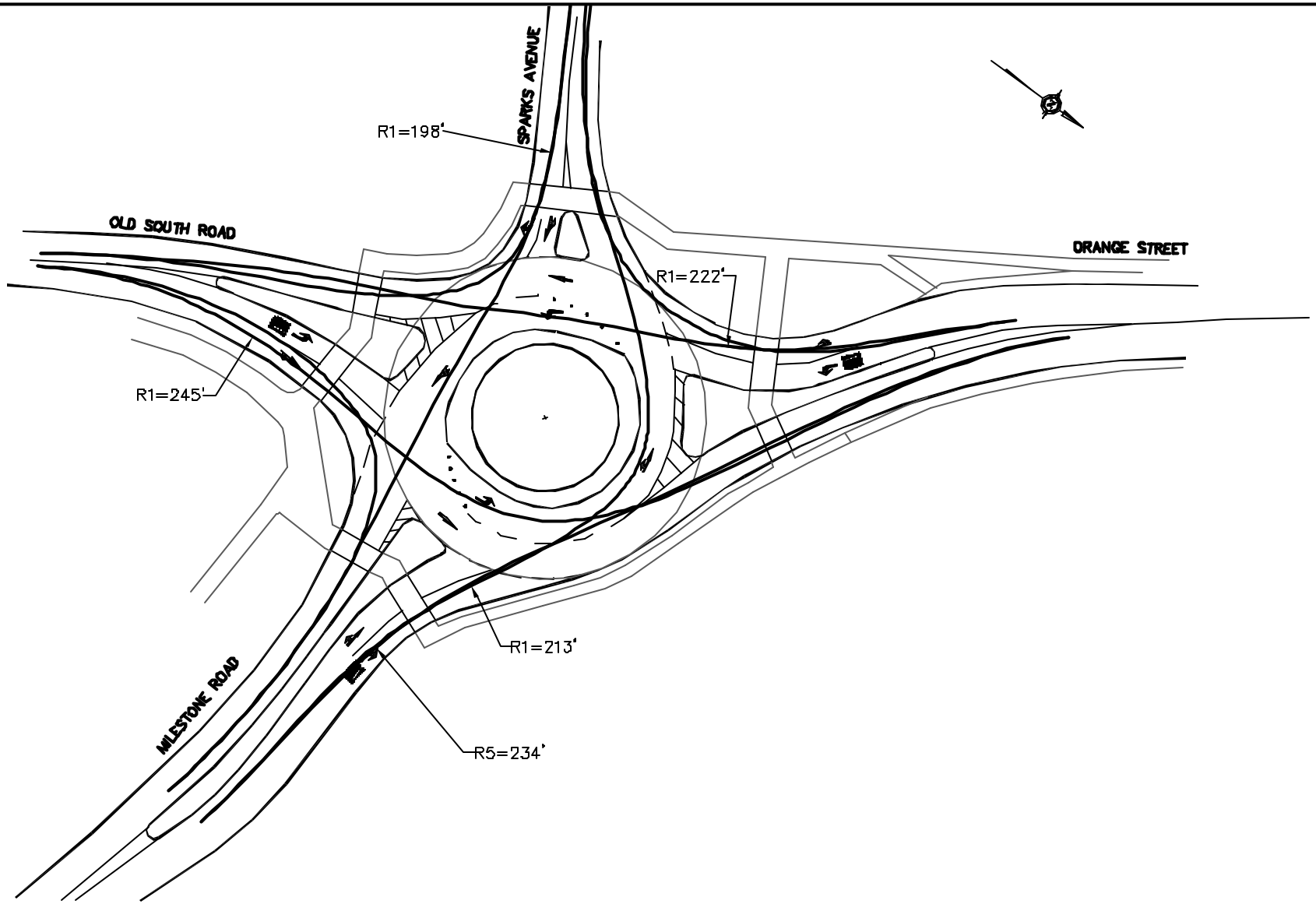

MILESTONE ROUNDABOUT - CRITICAL DEFLECTION CHECKS
MILESTONE ROAD / ORANGE STREET / OLD SOUTH ROAD / SPARKS AVENUE
NANTUCKET, MA

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DATE	PROJECT NO.:
AUG, 2006	0691.4
SCALE	FIGURE NO.
NTS	5

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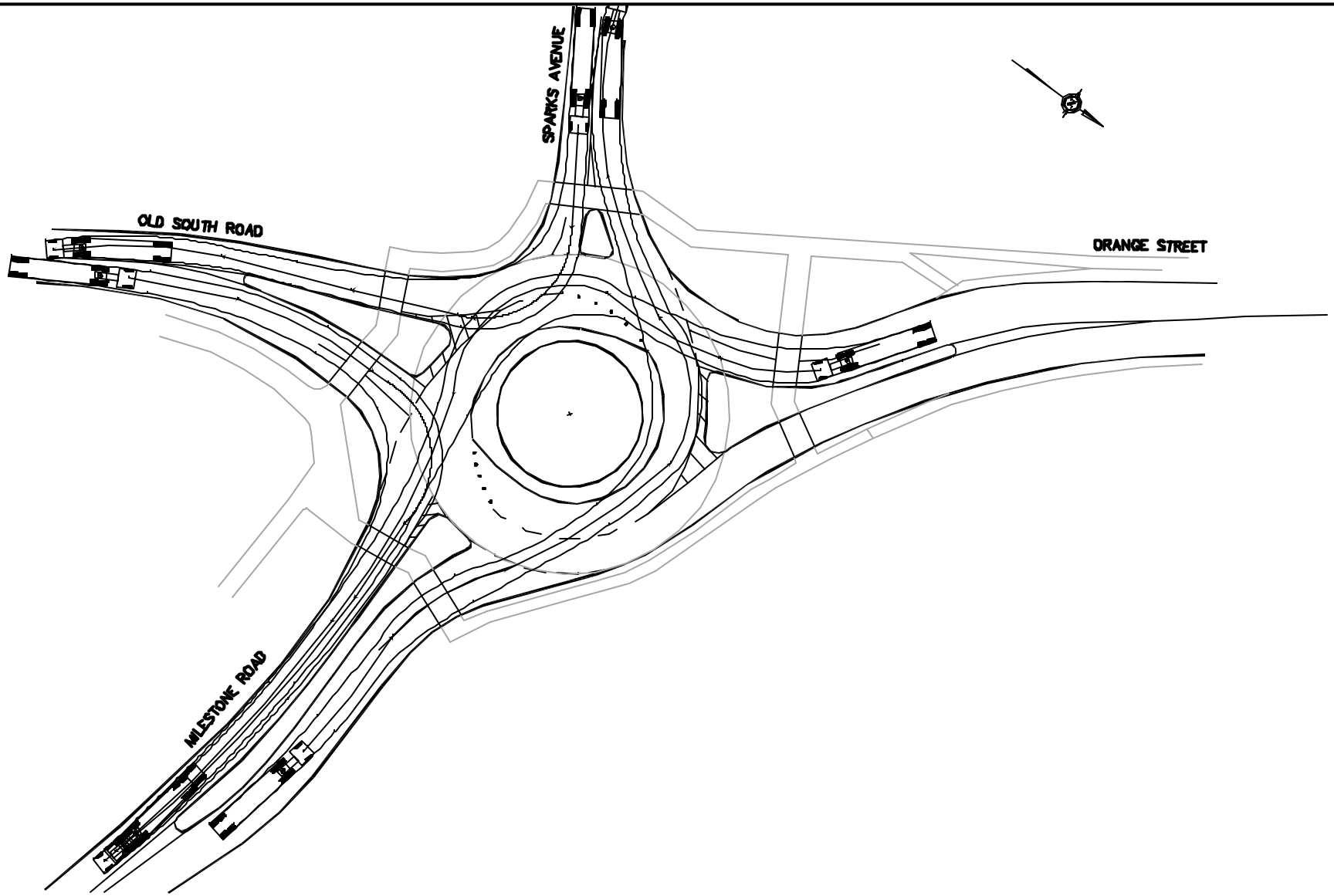

MILESTONE ROUNDABOUT - SELECTED DESIGN VEHICLE MOVEMENTS
MILESTONE ROAD / ORANGE STREET / OLD SOUTH ROAD / SPARKS AVENUE
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DATE	PROJECT NO.:
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SCALE	FIGURE NO.
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